THE HAYFORD

PROCESS AND APPARATUS

—FOR—

Preserving Timber.

By EDWARD R. ANDREWS.

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1878.

"*Wood thoroughly Creosoted is practically Imperishable.*"

IMPROVED

Processes and Apparatus

—FOR—

PRESERVING WOOD.

Patented in the United States, Great Britain, France and Belgium.

Edward R. Andrews,

PROPRIETOR,

Office, No. 4 P. O. Square, Boston.

HAYFORD PATENT CREOSOTE WOOD-PRESERVING WORKS,

A Street, South Boston.

Contracts taken for furnishing Creosoted Lumber or Railroad Ties. Contractors, etc., can furnish their own lumber for treatment.

Licenses granted for the use of the Hayford patents, under a Royalty.

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THE HAYFORD

PROCESS AND APPARATUS FOR PRESERVING TIMBER.

By EDWARD R. ANDREWS, of Boston.[1]

Mr. President and Gentlemen, Members of the Franklin Institute:—I wish to invite your attention, this evening, to a consideration of the natural and mechanical principles involved in the "Improved Processes and Apparatus for Preserving Wood," patented by Ira Hayford, Boston.

As introductory to the main subject, a few statistics of the rapid consumption of the timber of this country, an explanation of the causes of decay in wood, and the scientific principles which are the basis of every successful method of arresting and preventing decay, will not be out of place.

The subject of *wood-preserving* has not received the attention of scientific and practical men in this country, which its importance as a valuable industry demands for it. In Europe it is not only well understood, but preserved wood is generally used.

Maxime Paulet, a French chemist, in a large octavo volume on this subject, published in 1874, mentions not less than 173 different processes and apparatus, which have been patented or described in scientific works since the year 1700.

The most valuable systems were discovered between 1832 and 1838. Kyan, Bethell, Burnett, and Boucherie—whose names have been given to the methods employing corrosive sublimate, creosote, chloride of zinc, and sulphate of copper—introduced their several

[1] Paper read before the Franklin Institute, January 16th, 1878, and before the American Soc. of Civil Engineers, New York, Jan. 29th, 1878.

systems during that short period. All of these are in use in Europe, and scarcely any others; three of them, to a very limited extent, in this country.

In Europe, the use of preserved timber is the rule; here, it is the rare exception. Abroad, no question arises as to using preserved wood, and seldom as to the method; except in France, where sulphate of copper is largely used for railway ties, the Bethell system, or the impregnation of the pores of wood with the heavy oils of tar, known as creosote oils, has almost entirely superseded every other system.

In this country, the apparently inexhaustible supply of timber has retarded the general use of preserved wood. Yet, for some years, it has become evident that our supply is not inexhaustible. The drain is enormous; many parts of our country have been stripped of forests altogether. The statement is made, in *Scribner's Monthly* for December, that the annual lumber product of the whole country is ten thousand millions of feet. A very considerable portion of this product is to replace what was cut four to ten years before, and has decayed.

Consider for a moment the consumption of wood in the one item of railroad ties. Massachusetts, employing mostly chestnut ties, which last on an average six years, uses up in this way, annually, a volume of lumber nearly equal to the whole product of Maine; and the 80,000 miles of track in the whole country, allowing four years as the average life of ties, actually use up in ties alone one thousand six hundred millions of feet annually, or equal to one-sixth of the timber product of the whole country.

Add to this the consumption of wood for fences along the lines of railways, the bridges, platforms, etc., and it is easy to see that if some effort be not soon made to lengthen the life of railroad timber, the supply will become insufficient.

There are also 76,000 miles of telegraph poles, requiring for their renewal annually 43,620,000 feet of wood, or nearly equal to the product of the State of Maine. Telegraph poles were first creosoted in England, twenty-seven years ago, and are as sound as at first, to-day. The English government is now creosoting all the telegraph poles in the United Kingdom.

In view of these facts, added to the cost of labor attending the renewal of decayed wood, it would seem that this country ought to be

alive to the importance of preserving wood, in view of the results of European experience.

I do not find there is any lack of interest in this subject, only a lack of knowledge and of faith. That there is a lack of faith is not strange, because, as a rule, preserving has not added much to the life of timber in this country. This is, no doubt, partly due to the fact that those who have constructed works here, have put up a flimsy structure to fill some contract, or had some stock-jobbing operation in hand, but also partly to the fact that the systems in use abroad are not fully adapted to meet the wants of this country.

Had either European system been so, it certainly would have become general ere this. Our railroad engineers would not have continued the use of natural wood for ties, which last only four to six years, if through the use of the Bethell system their life could have been increased to twenty or thirty years, as in England.

Here let us consider what decay in wood is, what it is caused by, and what is needed to prevent it. There are two kinds of decay, known as *Wet Rot* and *Dry Rot.*

Wet Rot takes place in wood containing sap, which is exposed to moisture. It often commences in a living tree. It shows itself in the red streaks in the wood when felled, and woodmen recognize its existence even before the tree is cut down. It is wet rot which destroys railroad ties, fence posts, telegraph poles and bridge timber. It is hastened by alternate moisture and dryness.

Dry Rot, so called, needs moisture for its development as well as wet rot. It occurs in close, confined, damp localities, where there is imperfect ventilation. As a rule, it flourishes most actively in unseasoned lumber, but it also attacks seasoned lumber, when so placed that it can absorb moisture from its surroundings. *Dry Rot* is that sort of decay which is found in cellars and basements, between the ceilings and floors of houses, etc. Wood used in such localities is often already in a state of decay when placed there. It comes by cars or vessel direct from the saw-mill, and is framed at once, reeking with sap and moisture.

It is dry rot which destroys vessels, owing to confined air; the short life of wooden vessels is mainly attributable to this cause, and several of the methods for preserving wood were first used to prevent decay in the British Navy.

In localities where dry rot exists, and has destroyed one set of timbers, the seeds of decay are there still, ready to attack new timbers, unless the conditions can be entirely changed by ventilation or otherwise, and often such a change is impossible.

What is the cause of wet rot and dry rot? It is due primarily to the fermentation of the albumen of the sap, which commences as soon as the necessary conditions, heat and moisture, are provided. In a living tree, the unmatured sap rises from the ground through the sap wood, and after being transformed by the action of the leaves into true sap for the formation of woody fibre, it descends within the bark loaded with sugar, acids, albumen, etc., and forms the annual growth of wood, holding in abundance rich sap within its cells and fibres. So long as the tree lives, these processes go on naturally, but when the tree is cut down, and the leaves no longer perform their functions, the abundant sap clogs the pores, and is in a favorable condition to be acted on by heat, and begins to ferment.

Fermentation causes the rapid development of countless myriads of spores of fungi, always present. Animalculæ and insects follow, and the woody fibre is in time disintegrated, and although perhaps retaining the form of wood, it has lost all its strength and tenacity, and crumbles into pieces at the slightest blow. Rot is, then, the growth and development of fungus and animal parasites.

Preserving Processes.

The prevention of the development of fungus, or its destruction with the animal life it nourishes, is, then, the object of the various processes for preserving wood. The coagulation of the albumen of the sap is the only result obtained by the use of the metallic salts. Coagulation prevents the albumen from fermenting, and the spores of fungi lie dormant; both vegetable and animal life are arrested. As a protection against dry rot, is not exposed to moisture, where wood these systems are useful, but when wood is exposed to water, they are of little value, as a rule. They consist in impregnating the pores of wood with watery solutions. It is certain they will partially redissolve by water, and leave the wood unprotected, always liable to absorb water carrying with it destructive elements.

It is important, then, that the public should not confuse creosoting with Burnettizing, etc. These only act chemically upon the sap, but creosote oil, containing carbolic acid, cresylic acid, etc., not only

produces the same result chemically, but also secures *dryness*. Creosoting fills the pores of wood with an insoluble oil, and covers the fibres with a film, which protects them from absorbing destructive elements from extraneous sources. The oil, which saturates the sap wood, and the outer pores of the heart wood, resinifies and hardens under the action of the air, and forms a waterproof and air-tight covering to the wood. If the heart wood be not too dense, it also absorbs a large quantity of oil, otherwise the oil absorbed by the sap wood works inwardly, being very penetrating in its character, and, in time, can be plainly seen through the whole tissue.

It is *dryness*, then, and the waterproof and air-tight qualities imparted to wood by its impregnation with creosote oil, which give it its superiority over every other substance used for preserving wood. The presence of heat and moisture is necessary to induce decay; heat without moisture is harmless. Wood absolutely dried by some artificial process of desiccation will not decay, if it can be kept perfectly dry afterwards; hence, wood, which has been dried, has been preserved. Wood once dried, and then so protected that it can under no circumstances absorb moisture, has been rendered practically imperishable, except from wear.

When wood has been treated by the Bethell system, if the work has been faithfully done, it will not absorb moisture, and is, therefore, well preserved against decay.

Why, then, is not the Bethell system sufficient, you will ask? The answer is simply because only dry wood can be effectually treated by the Bethell process, and in this country we must treat green lumber. No system of wood-preserving can be made practicable here, which does not embrace some effectual method of drying green wood rapidly.

This defect of the Bethell system has always been recognized in Europe, where ties and timber intended for creosoting, are stacked up from nine to twelve months to season.

At a discussion on the preservation of telegraph poles, in 1876, Mr. Braine, Superintendent for J. Bethell & Co., London, made these remarks: "Dryness is the principal quality required in timber that is to be creosoted. Timber is sometimes delivered *dripping wet*, and the creosoting firm expected to creosote it without delay. * * * * * It is perhaps better that timber should not be creosoted at all than creosoted moist."

With us timber is used directly from the cars or vessel. We cannot wait for timber to season. It is not cut from the log until needed for construction. We must be prepared to take timber as it comes from the saw-mill, and in a few hours season and preserve it.

The Bethell system will not do this; oil and water will not mix together. So long as the pores of wood are reeking with sap and river water, it is impossible to inject into them any preservative substance. Hence, it is evident that the Bethell process needs some radical modifications before it can be adapted to the wants of this country. These modifications are precisely what have been made in the *Hayford* patents.

The important claims of the Hayford process are: *Dryness* before impregnation with any preservative substance, a complete coagulation of the albumen of the sap by heat, the evaporation of the watery portions of the sap, and the withdrawal of all moisture, sugar, acids, etc., in vacuo, leaving a pure wood fibre, fully preserved against decay, except from contact with air and moisture. There is no patent for the use of creosote oil. The Hayford patents cover improved processes for preparing wood to receive any preservative substance required, and apparatus for injecting such substance into the pores of wood thoroughly and rapidly.

Apparatus.

I will now describe, as clearly as I can, the apparatus used in the Hayford process, and then try to show wherein it brings about the results I claim. The apparatus is simple and strong. At my works at South Boston, I have endeavored to have perfect security from accident, and, at the same time, the best-fitted and strongest plant ever erected for wood preserving.

It consists mainly of an 85-horse boiler, a pump, a tank to contain oil, and a cylinder in which the wood is treated. The *cylinder* is the most important part of the works, and upon its perfect construction depends the commercial success of the enterprise. It is 100 ft. long, 6 ft. in diam., made of $\frac{1}{2}$ inch boiler iron steam riveted. On either end, a cast gun-iron ring is riveted, which serves as a jam to a wrought-iron door made of plates $\frac{5}{8}$ inch thick, bent to a semi-globular form and riveted to a gun-iron ring of same dimensions as the ring on the cylinder. This door is hung to the cylinder by a hinge, which, however, acts as a guide only, the weight being

supported by a strong wheel, which rolls on a track with a solid foundation. A rubber gasket makes the joint between the rings perfectly tight. The cast-iron rings are pierced with bolt holes, through which 36 bolts pass. On one end of each bolt is a case hardened nut, and at the other is pierced an eye, into which slips one of a series of steel keys, arranged upon a ring, which revolves about the cylinder by a screw motion, by which means all the bolts are fastened or unfastened at once. It is necessary to give a few turns to the nuts with a wrench, to make the joints perfectly tight, before commencing a treatment, or to loosen the strain when the treatment is over, and the doors are to be opened; but by this simple mechanical contrivance, the great labor of opening and closing the doors is made comparatively easy.

The cylinder rests on rollers, to allow for expansion and contraction, supported on brick piers. This cylinder is a perfect piece of boiler work, and has been tested by hydrostatic pressure of 200 pounds to the square inch. There is no leakage during the process, when the pressure reaches from 100 to 150 pounds. Great annoyance has been frequently experienced with cylinders made for wood preserving on account of leakage, and danger also from want of strength in the heads, generally of cast iron, which broke under the required strain.

A railway track, 3 feet 4 inches wide, runs through the cylinder, and extends 100 feet beyond at either end, so that iron cars can be loaded with lumber at one end and be discharged at the other. Between the tracks, at the bottom of the cylinder, lies a coil of steam-pipe 1400 feet long, which connects with the boiler at one end, and at the other has outlets both with the outer air and with the inside of the cylinder, that the steam, after passing through the coil, can be allowed to escape into the cylinder when desired.

A series of perforated pipes is arranged around the inside of the cylinder, for the purpose of introducing the oil. These are connected with the oil tank. They are so arranged that, when the oil is let on through them, every stick of wood in the cylinder is at once bathed with oil.

The *oil tank* is simply a receptacle to contain the oil, and of capacity sufficient for the purpose. It is strong enough to stand a pressure of 100 pounds to the square inch. A coil of steam-pipe, connected with the boiler, is laid through it for the purpose of heating the oils to the required fluidity.

A simple, but powerful, pump is so provided with valves and pipes that by opening one set of valves and pipes it is a force pump, and by closing these and opening another set it becomes a vacuum pump. A water-jacket around the air-chamber keeps it cool while in operation. The necessary piping to connect the parts together completes the apparatus.

Hayford Process.

The first part of the process is for the purpose of drying the timber.

The wood to be treated has been placed upon iron cars, and run into the cylinder, which is hermetically closed. Steam is then admitted through the coil in the cylinder, and after passing through the coil, it escapes into the cylinder itself. The temperature in the cylinder very soon reaches 180° Fahr. It rises very slowly from this point, the evaporation of the sap and moisture in the wood tending to cool the temperature. It is best that the heat should increase gradually and that it should be kept moist. If allowed to be too dry, the outer fibres of the wood naturally harden, and thus prevent the escape of the moisture within. To avoid this, and also to save all the heat, the exhaust from the pump is also admitted into the cylinder. The pump is set at work to force atmospheric air into the cylinder, until the pressure gauge shows a pressure of 30 to 40 lbs. to the square inch. The object of this is to keep the wood from checking; green wood, in large dimensions, when exposed to high temperature, has a tendency to check. A vacuum forms about the wood, arising from the condensation of steam, and the expansion of the moisture within the wood tends to throw apart its fibres. This tendency is counteracted by the atmospheric pressure above stated. And thus a higher degree of heat can be used in drying the wood without injury to its fibres. 250° to 270° are sufficient to evaporate the sap.

During the steaming process, a pipe in the bottom of the cylinder is kept open, to allow the escape of the condensation. By the same means is maintained a current of hot air, which is very efficacious in drying wood. The time necessary for drying wood in this process depends upon the quantity of moisture to be got rid of, and the size of the timber. Four or five hours suffice for boards and 2-inch plank, while ten or twelve are required for heavy timber.

Albumen coagulates at 140°, so that that result—the only one claimed for the Burnettizing and Kyanizing processes—is easily secured; but the sap and moisture cannot be got rid of, until they have been turned into vapor. Hence the necessity for continuing the steaming process until it is certain that all the portions of the wood containing sap and vapor have been heated to above 212°.

When this point is reached, the direct steam is cut off, all valves opened, and the air pumps kept at work to drive from the cylinder all the steam, vaporized sap and condensation, which remain in the cylinder; in other words, to free the cylinder entirely. This occupies about an hour, and closes the second part of the process. Heat is constantly maintained through the radiation from steam coil. We then commence to pump a vacuum.

The cylinder is once more made tight. The valves in the pipes connected with the pump, which made it a force pump, are closed; and those opened, which change it into an exhaust or vacuum pump. The vacuum pump is then set to work. There is, at this time, no appreciable amount of moisture in the cylinder, except what exists in the pores of the wood in the form of vapor. The vacuum pump has worked but very few minutes, however, when the vapors, partly condensed in the pump, begin to pour from the nose of the pump, and they continue to come for hours, filling, if the wood be green, many barrels with sap.

This shows the effect of the steaming process. If a cold vacuum had been pumped, when the cylinder was first closed, it could be easily done in less than an hour, but no water would have come through the pump, and the wood would not have parted with its sap. It is a common mistake to suppose that a vacuum alone will withdraw sap from wood. But after steaming, when the sap has been turned into vapor, then it is drawn out by the force of the vacuum pump, yet the vacuum is reached very slowly, on account of the vast quantity of moisture which is drawn from the wood; five or six hours often elapse before the vacuum gauge indicates 24 or 26 inches of vacuum. But the sap having been withdrawn, the vacuum extends into the interior of the wood, if it can be properly so expressed, so that when the oils are let in, they are absorbed into the very heart of the wood.

This brings us to the last step in the Hayford process, namely, the impregnation with the preserving material. During the drying process,

steam has been admitted to the coil in the oil tank, bringing the temperature up to about boiling point, to render the oils very limpid and penetrating. Creosote oil is heavier than water, weighing about $9\frac{1}{2}$ pounds to the gallon, it congeals at about 60°, so that heat is needed to make it flow freely.

Impregnation.

I have previously explained to you that the oil is admitted to the cylinder through a series of perforated pipes, arranged around the inside of the cylinder. A pressure of about 60 pounds to the square inch is brought to bear upon the top of the oils in the oil tank; this pressure, together with the drawing force of the vacuum, make a force of about 75 pounds to the square inch, with which the oils are sucked and driven into the cylinder. Every stick is at once bathed with oil. The wood—being in a soft, somewhat spongy condition, the fibres porous, and the pores open—absorbs at once the hot, penetrating oil. If the wood be of a porous character, like pine, it absorbs all the oil required with the first flowing over of the oils, without any pressure; but if the fibre be solid and close, and the timber of large size, a further pressure of from 60 to 150 pounds is needed during a certain length of time to make the impregnation complete. But the wood having been put into a condition to absorb the oil, the impregnation is more rapid and more thorough than by the Bethell process, where no other means are relied upon than a pressure upon hard, air-dried timber in a cold vacuum.

The process is now completed, and the doors at either end being opened, the lumber treated is withdrawn, and another charge takes its place.

Value of Process.

Now let us retrace our steps, and see whether, practically as well as theoretically, the advantages claimed for the Hayford patents have been realized.

I have shown you that to preserve wood from decay, it must be placed in the following conditions:

1. It must be rendered non-fermentable by the coagulation of the albumen of the sap.

2. *Dryness* must be secured by the abstraction of the sap and moisture contained in it, as well as any sugar or acids, which would have a tendency to ferment.

3. *Dryness* and a pure woody fibre being secured, these conditions must be maintained by protecting the wood in some way from air and water afterwards.

In reply, I claim: First, that inasmuch as albumen coagulates at 140°, and that all the sap containing albumen is to be found in the sap-wood, and that it has been steamed to 240° or 270° Fahr., the albumen has thus been rendered non-fermentable. Moreover, creosote oil contains the most powerful coagulator of albumen known to science—carbolic acid; hence, when injected into the pores of wood, it doubly secures it from fermentation.

Secondly. By the action of the steam heat, and the subsequent use of the vacuum pump, the sap and water held in the wood have been vaporized and withdrawn from the pores of the wood, leaving a pure woody fibre. Nothing liable to ferment remains in the wood.

(This system of drying lumber can be made very valuable for carpenters. In twenty-four hours green lumber can be seasoned more completely than in an ordinary dry-house in six weeks. For this purpose the drying process should be continued for some time after the vacuum has been reached, the heat being kept up by the radiating coil of pipe.)

Thirdly. Freedom from liability to fermentation and dryness being secured by the earlier processes, the wood is made water-proof and air-tight by injecting the pores with creosote oil.

Creosote oils are also called dead oils, or the heavy oils of tar. They contain from 5 per cent. to 15 per cent. of carbolic acid, and several other highly antiseptic and preservative constituents, besides paraffine, naphthaline, etc., which all play their parts in the preservative processes. Heavy oils are produced in the distillation of crude coal tar, as it comes from the gas houses. They come off after the light and volatile aniline oils, say at a temperature of 300° to 600°. The residuum is pitch.

Creosote oil, forced into the pores of wood at a high temperature, being far more penetrating than any other oil, works its way through the pores until it covers every fibre with a protecting film. It resinifies in the outer pores, and, impacting there, keeps the main body of oil within, and, being insoluble in water, it forms a water-proof and air-tight covering to the wood, and maintains absolute *dryness*. No matter where the wood may be exposed, it is protected from absorbing any fermentable substance. Hence, decay is rendered almost impossible.

The preservative qualities of the heavy oils of tar are not due, solely or chiefly, to one or more of its component parts, although several are esteemed highly as preservative substances; but their efficacy is due, chiefly, to the thick, greenish oil itself, which is *insoluble.* It is this quality, *insolubility*, which gives to the heavy oils of tar their superiority, as preservatives, over chloride of zinc, sulphate of copper, or corrosive sublimate. These latter only coagulate the albumen, they offer no protection whatever to the wood itself; the woody fibres are as much exposed as ever to absorb destructive agents. But when wood has been injected with creosote oil, which works insidiously through its fibres, not only is the albumen coagulated, but the whole structure is so absolutely preserved and protected, that its indestructibility is assured, except from actual wear. It is benefited on this score, also, as it becomes harder by time. Creosoted wood is the only wood which seems to improve with age. The oil seems to metalize the fibre like iron. Soft wood becomes hard, like oak. Sap wood becomes as hard and durable as the heart-wood.

In the early part of my remarks I stated that the Hayford patents, for preserving wood, covered a system which is adapted to the wants of this country. This is mainly, as you have observed, because it is able to cope with green lumber. It can receive it from the saw-mill, and in 24 hours thoroughly season and preserve it. In fact, to do good work it is essential to have green wood. It is precisely in this condition that wood will readily absorb creosote oil, when the moisture has been withdrawn. In a living tree, the fibres and pores of wood are not hard and flinty, like those of kiln-dried or air-seasoned lumber, but are soft and porous. The cells act as so many millions of pumps, to transmit the sap from the roots to the leaves and return it again to form the annual layer of wood growth. When the sap has been withdrawn from wood in this condition, as has been described, without hardening the fibres, the cells and fibres are just as ready to receive or transmit creosote oil as sap itself.

Creosoted Wood will not Decay.

I have assumed that you are all familiar with the fact that wood thoroughly creosoted will not decay. This is a fact, proved by the accumulated evidence of 40 years in England. Creosoted wood has never been known to decay. Engineers in this country need not wait

a generation to learn that this is so. It was accepted as proved in England 30 years ago, and in engineering works the strongest testimonials of the value of creosote oil, as a preservative against decay, are recorded by all the great constructive engineers in Europe.

There is scarcely a railway in England which does not use creosoted ties, bridge timbers and platforms, and the same roads use them to-day which began their use in 1840. The Belgian system of railways, which is under government management, uses creosoted ties solely, and the same is true of all the railways of Northern Europe.

Some engineers here have told me that ties wear out before they rot. That may be true in some cases; but I ask, if creosoted ties do not wear out in 20 years on the great roads in England, why should they wear out here? It is a remarkable fact that it is difficult to find any old ties in England for specimens of creosoted work. These specimens from the Great Northern Railway of England, which have been in wear from 10 to 14 years, were actually taken out of the road-bed to be sent to me. No piles of old ties lying by the side of the tracks, only fit for fuel, are to be seen in Europe as in this country.

My belief is, ties begin to decay before they begin to wear out. As a rule, ties are half buried in the ground in a green state, full of sap in a fermenting condition. Wet rot sets in at once, favored by the exposure to alternate dryness and moisture, particularly under the rail, where the surface begins to decay at once, hastened by the rust from the rail; at the same time the spike driven into the moist wood begins to corrode; water works down by the side of the spike, the spike loosens and plays, and then comes the trip-hammer action of the rail every time a train passes over it. It is no wonder the tie cuts and is thrown out, often within the first year.

But with a creosoted tie the spike will not corrode and will not work loose; the surface of the tie under the rail will not decay or wear, because not affected by alternate dryness and moisture; there will be no play of the rail upon the tie, and consequently no friction and no cutting. No, there is every reason for believing that creosoted ties will last here 20 years as well as in England, and their general use would be equal to a saving of 3 per cent., per annum, on the cost of the railways of this country.

I have referred principally to the uses of creosoted wood on railways, because they are the great consumers of lumber, but it should commend itself equally to architects, builders and carpenters.

Creosote as a Protection against the Teredo, etc.

I have referred thus far to creosoting as a protection against decay only, but it is equally a specific against destruction of wood by marine worms. This quality of dead oils is almost as important as their efficacy against decay. Bear in mind that from Maine to Texas there is scarcely a point on our coast, where our piers and wharves are not rapidly destroyed by the Teredo Navalis, or the Lymnoria Terebrans.

On the table before me are specimens of wood destroyed by these ravagers at different points, in a few months or years, at Boston, Provincetown, New York, and the Gulf of Mexico.

So far as I am aware, the teredo is not found north of Cape Cod, but the lymnoria is scarcely less destructive.

In many places in the Gulf, the teredo will destroy large piles in a single year. They are found sometimes two feet long:

Places where Creosoted Wood has been used as a Protection against the Teredo, in Great Britain.	Dates. When exposed.	Dates. When last examined.	Duration.
Port of Sunderland, . . .	1839	1859	20 years.
" Teignmouth, . . .	1842	1849	7 "
" Lowestoft, . . .	1846	1859	13 "
" Leith, . . .	1848 1854	1862	14 " 8 "
" Southampton, . . .	1848	1852	4 "
" Brighton, . . .	1848	1851	3 "
" Manchester, . . .	1850	1861	11 "
" Portland, . . .	1853	1861	8 "
" Holyhead, . . .	1854	1861	7 "

The teredo infests the coasts of Great Britain, Holland, Belgium and France, and is quite as destructive there as here; were it not for the use of creosoted piling, the piers of their harbors would require to be rebuilt every three or four years. There is not an instance on record where a pile, impregnated with creosote, to the extent of 10 or 12 pounds to the cubic foot, has been approached by the teredo or the lymnoria. Piers built in 1850 are perfectly sound to-day.

The importance of protecting these harbor works has been considered so serious a matter, that most careful experiments have been

tried, extending through a series of years, under commissioners appointed by the different governments, whose official reports are accessible to all. Every other suggested remedy was tried, and failed in every instance. The terrible mollusk or crustacean seemed to fatten upon every poison, and would manage to work its way between copper- or iron-headed nails or copper plates, but he turned his back invariably upon creosote.[1] All the official reports agree upon this point, that creosote, and that alone, thoroughly injected into wood, will protect it completely.

There is, however, one other remedy, and that is sewerage. It is fortunate that sewerage serves one good purpose. These enemies require clear, salt water, free from any brackishness. It carefully avoids a pier in New York, where a sewer empties, but it luxuriates in the next, which is free from that nuisance.

The importance of creosoting ship timber should not be overlooked. I have specimens of birch before me taken from the side of a vessel, which had been six months at Key West, completely riddled by the teredo. How often may it be that vessels, lost at sea and never heard from, have sprung a leak through some teredo eaten timbers. Remember, too, that dry rot would be prevented also, and, perhaps, all necessity for copper bottoms. It would seem that creosote is as useful at sea as on land. Its use is everywhere a true economy.

Our own Government has the honor of being the first to creosote ship timbers. In 1872 creosoting works were erected at the navy-yard in Charlestown, under the superintendence of Mr. Hayford, who took charge of the treatment of the timbers for the "Vandalia," the vessel which is now the home of Gen. Grant, in the Mediterranean.

The ribs of the "Vandalia" are of live oak, but all the rest of the planking and decks, inside and out, were creosoted by Mr. Hayford. This vessel was completed in 1873, and fitted for sea in 1875. Thus far no report has been made of her condition to the Department.

It is well to select, for creosoting, woods which are porous and will absorb oil readily. Cheap woods, which, unpreserved, rot quickly,

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[1] See papers by E. H. Von Baumhauer, on "The Teredo, and the means of preserving wood from its ravages;" Archives of Holland, Vol. I, 1864. Auguste Forrestier, Engineer of Roads and Bridges; Annales Françaises, 1864. M. Crepin, Engineer of Roads and Bridges of Belgium; Report of experiments at Liege, from 1857 to 1867.

can thus be made more solid and more enduring than the most expensive timber. I think the cotton wood of the Southwest can be made as useful as oak for ties. White pine absorbs creosote like a sponge, and the yellow pine of the South takes it readily also. In England, fir from the Baltic is used altogether for ties, and I do not see why the despised fir from our forests may not be used for the same purpose here. Hemlock is good also; it holds a spike well. Spruce is a firm, compact wood, and absorbs oil with more difficulty, neither does it require so much to preserve it. Its sapwood, where decay commences, is always saturated, and the heart, if treated green, shows more or less oil all through the annular rings. Oak has a coarse fibre, and is easily treated.

The limits of a single evening are insufficient, Mr. President and gentlemen, to do justice to so important an industry as this. I thank you for your kind attention, and need not say that I shall be glad, as far as I can, to answer any questions which may lead to a clear and full understanding of a subject in which so many of you, I am sure, must feel a deep interest.

The speaker presented, in support of his views and statements, a large number of letters from engineers in this and other countries, referring to some important works where creosoted timber had been exposed for many years, with the most satisfactory results: among which are the Yorkshire and Lancashire Railway, England, Southern Railroad, France, the Leith Pier, Edinburgh, Scotland.

Among the letters is the following, referring to the

WEARING OF RAILROAD TIES.

"*Boston, Feb. 6th*, 1878.

"EDWARD R. ANDREWS, ESQ.,

"*Dear Sir:*—In answer to your enquiry, I will repeat what I said at a recent meeting of the Boston Society of Civil Engineers, on the subject of treated and untreated railroad ties. I have been of the opinion for some ten or twelve years, that the frequent remark that 'railroad ties will wear out (*i. e.*, cut through) before they will rot out,' is an incomplete and misleading statement, as it is usually made. It supposes that treated (creosoted, kyanized, Burnettized, etc.) railroad ties will wear and cut the same as untreated ones; whereas the *fact* is, as shown by the records of foreign railroads,

beyond dispute, that treated ties *wear* longer, do not *cut through* so quickly, and hold the spike longer than untreated ties. I have my own explanation of this fact, but whether the same is correct or not, is really a matter of no especial importance. What we are after are the facts. Still, I will give the explanation that I have arrived at for my own satisfaction, submitting the same to criticism. It is that, after all, what we call 'cutting through,' 'wearing out,' 'refusing to hold the spike,' etc., in railroad ties, is nothing more or less than rotting, with this single distinction, that it is a local rotting, a decay in certain spots and places only, and not that of the whole body of the tie; and that, therefore, a treated tie, which resists decay better, any and everywhere, within it and on its surface, will wear longer, cut less, and hold the spike longer.

"The first time I had occasion to reason in this manner, was in observing the dropping down into the ties of the cast-iron chairs of a piece of 'English' double-headed rail track on the Boston and Albany R. R. The chairs were frequently an inch and an inch and a half imbedded in the tie, and the cup so formed was filled with water after every slight rain or heavy dew, and it seemed to me plain that this concentrated wetting and drying in that spot could not fail to rot the tie faster right under the chair than elsewhere; and adding that to the pounding action of the traffic over the road in the same spot, it made clear to me why the tie wore out before it rotted out, and at the same time satisfying me that a 'properly treated tie' would behave better under the same circumstances.

"Respectfully yours,

"CLEMENS HERSCHELL,

"*Civil and Hydraulic Engineer.*"

TESTIMONIALS AS TO THE EFFICACY OF CREOSOTE OIL IN PRESERVING WOOD FROM DECAY, AND THE ATTACKS OF MARINE WORMS.

Extract from a letter, written by James Forrest, Secretary of "The Institute of Civil Engineers," London.

"*London, England, 8th June*, 1877.

"EDWARD R. ANDREWS, Esq., Boston.

"*Dear Sir*:—In continuation of my letter of 31st ult., I have to say that one of the principal 'creosoters' in this country, states, in reply to my enquiry, that 'there is nothing very fresh or recent to communicate on the question of creosoting timber; it is now almost universally used in England for the preservation of sleepers and other timber for engineering purposes, and also for the preservation of timber employed for piers and harbor work in sea-water infested by marine insects, such as the teredo navalis, and the lymnoria terebrans, against the ravages of which, when properly and thoroughly employed, it has been found to be quite efficacious.'

"The whole of the creosote produced from the distillation of tar in England, is now used for this purpose, and it has often been a matter of surprise that the Americans have not used this process in their country, as they have coal tar there, which they could distil.

"In France, Belgium, Holland and Germany, the use of creosote is steadily on the increase.

"Yours, Faithfully,

"JAMES FORREST, *Secretary*."

Office of the Superintendent of Streets, City Hall.

Boston, Jan. 14*th*, 1878.

EDWARD R. ANDREWS, ESQ.

Dear Sir:—Ten years ago, when I built the house where I now reside (179 Warren Ave.), I put down a border of pine wood around the flower beds in the back garden. At the expiration of three years these borders were so much decayed, that I was obliged to replace them, which I did with wood creosoted by Mr. Hayford. To-day these creosoted borders, after being in the ground seven years, are perfectly sound. I cannot discover a single decayed spot in them, not even in the joints.

A year ago I made a slight alteration in the garden, and took up a piece of the border about three feet in length, which I gave Mr. Hayford to show to you, a short time ago, and which I presume you have now in your possession. It is painted green on the portions which were exposed to the air, the other portions were covered in the garden loam. The border still in the garden is in as good condition as the piece in your possession. Yours very truly,

CHARLES HARRIS,

Superintendent of Streets.

Boston, 14*th January*, 1878.

MR. EDWARD R. ANDREWS, No. 4 Post Office Square, Boston, Mass.

Dear Sir :—In response to your enquiry, we take pleasure in stating that in June, 1872, we laid a flooring on our cellar, using planks creosoted under Mr. Hayford's process; this flooring is exposed to the atmosphere and to the ebb and flow of the tide, being frequently submerged. During the present winter, while making extensive alterations in our buildings, we were compelled to take up a large portion of this flooring, and found all the planks so moved in a perfect state of preservation, as good, apparently, as when first laid.

We are, very truly,

GEO. F. BLAKE MANUF'G CO.

Manchester Mills.

Manchester, N. H., April 16*th*, 1877.

EDWARD R. ANDREWS, ESQ., Boston.

Dear Sir :—Your favor of the 14th rec'd. The floor referred to was formed by bedding the timbers in the dirt, three inch plank laid on them, and a board floor over the plank.

The timbers and plank were of spruce, and prepared by a process of creosoting. This floor was laid some six years ago, and thus far shows no sign of decay. The timber so treated becomes very light, dry, and does not warp, but of some 500 M ft. of creosoted spruce that I have put in wet, damp, and poorly ventilated places, none has as yet given out, although No. and So. pine have rotted in the same places in four years. Yours truly,

J. STONE, Agent.

38 King William Street,

London Bridge, E. C., June 11th, 1874.

Messrs. J. G. Moore & Co., 96 Wall St., New York.

Gentlemen:—As it appears you have never received ours of January 29th, in which we promptly answered yours of January 9th, we repeat it as follows:

We can put 10 lbs. creosote per cubic foot into yellow pine, and have put 12 lbs. into some red fir, but this is rarely done. The usual quantity injected is 8 lbs. for ordinary timber, and for timber exposed to the sea worm 10 lbs. Of white oak we have no experience, but we are creosoting French oak in Belgium, and also oak from the Baltic. Into sleepers of such wood we put from 3 to $4\frac{1}{2}$ lbs., sometimes 5 lbs. * * * * * It is impossible to drive the oil into the heart of the wood; the sap of the wood is impregnated and a waterproof coating or envelope is thus formed, which renders the wood impervious to air and moisture, the oil dissolves the resin of the sap and coagulates with its albumen, and follows in deeper in the course of time to the centre of the wood. * * * * * We have assumed that you do not require any evidence as to the value of creosoting as a preservative. We have lately, since the adoption of the process by all the government and railway engineers, ceased to collect evidence, but we shall always be very happy to send you any which has come in our way. We are, gentlemen, yours faithfully,

John Bethell & Co.

New York, May 28th, 1870.

Sir:—In reply to your inquiries concerning the preservation of wood in Europe, I beg to say that one of the principal objects of my recent trip abroad was to obtain full and accurate information upon this most important subject.

My investigations were conducted in England, Scotland, Ireland, France, Belgium, Prussia, Russia and Austria, and were continued for nearly four months.

On several of the roads I traveled over, I found creosoted ties were already over twenty years in use, and still sound as when first laid.

Baltic fir—a timber resembling American hemlock—is generally employed for ties in Europe. When creosoted, it lasts without decay as above stated; while, uncreosoted, it decays in from three to four years.

The spikes driven into these creosoted ties show no corrosion whatever after this lapse of time, and the rail is consequently held more firmly to the tie.

I found the density of the wood much increased by the action of the oil, the fir ties acquiring almost the density of our oak.

The use of these creosoted Baltic ties is almost universal upon the following, among other roads, which I observed, many of which have a heavier and more constant traffic than the average of American railroads, viz.: Lancashire and Yorkshire; London and North-western; London, Chatham and Dover; Midland; Dublin and Drogheda; Midland Great Western of Ireland; Great Southern of Ireland; Great Northern, of France; and the railways composing the lines from Paris to St. Petersburg, via Cologne and Berlin; Berlin to Vienna, via Dresden and Prague; Vienna to Paris, via Munich and Strasbourg; and Paris to Brussels.

I must say, in conclusion, that an experience so thorough and exhaustive, with results so satisfactory, should be accepted as sufficient, and that we should await for no similar experiments here to convince us of the economy, as well as practicability, of preserving our timber by the use of creosote oil. Yours, etc.,

George Shepard Page.

Lancashire and Yorkshire Railway.

Manchester, *August* 14*th*, 1865.

Last month I visited a portion of the line which had been laid with these sleepers in 1846, and I am glad to be able to report that the whole are as *fresh and sound as when first laid down, not the least signs of decay being apparent.*

During a period extending over upwards of nineteen years I have creosoted about one million of sleepers, and large quantities of timber of various kinds, and from all my experience, gained during that time, I would strongly recommend to be creosoted all timber to be placed in exposed situations, such as sleepers, telegraph poles, lamp posts, fencing, etc. I remain, dear sir, yours very truly,

R. J. Badge.

P. S.—The creosoted road generally wears out three or four sets of rails in, as well as out of, tunnels; and when the main line is relaid, and such sleepers are taken out, they are used again for sidings and branches. I find that about one per cent. get split at the ends, and so rendered useless for their original purpose, but they are then sold for gate posts, fencing, etc., and are much sought after.

Lancashire and Yorkshire Railway.

Storekeeper's Office, Miles Platting,
Manchester, February 27th, 1874.

D. M. Owen, Esq.

Dear Sir:—You stated that your friends expect that we should force the creosote through and through. This cannot be done, *and is not necessary;* but after a piece of timber has been tanked, cross-cut it, say a foot from the end, and place it in the hot sun, for a few days. You will then see how far the lighter parts of the creosote have filtered towards the centre.

For your information, I may state that this company have tanked, under my superintendence, over 1,500,000 sleepers, besides longitudinal and crossing timber, and if the process has only prolonged the life of the timber by one-half, I think I have saved the company a considerable amount of money.

I took up a couple of paving blocks, that have been in our turning shop under grindstones and lathes, exposed to wet and dry for *twenty-six years;* they are in perfect condition, showing no signs of decay.

Respectfully,

R. J. Badge,

Mechanical Engineer, Lancashire & Yorkshire Railway.

TRANSLATION.

Southern R. R. Co., France, Office 54 Boulevard Haussman.[1]

Paris, December 24th, 1877.

Monsieur Gruner, Inspector General of Mines, Paris.

Dear Sir:—In reply to your favor of 21st Nov. ult., asking for information regarding the use of pine ties creosoted by this company, I have the honor of addressing you the following statement.

(Signed) E. Huyot,

Director of the Company.

EXTRACT ONLY.

"The first creosoted ties used by this company were placed in 1857 to 1860. They were prepared by a contractor, and impregnated with 7·272 kilos. of oil per tie.

"The company creosoted at their own works in 1869 about 10,000 ties, using 14·090 kilos. per tie.

"The company is now having ties creosoted by a contractor, using from 5·454 to 7·272 kilos. per tie.

[1] Chemin de fer du midi from Paris to Bordeaux.

"The pine ties prepared with creosote do not show, at the end of seven or eight years, any appreciable alteration in their exterior character. This is the report upon the actual condition of the ties prepared and put to work in 1869. The company has no precise statistics as to the duration of the pine ties, creosoted and used from 1857 to 1860, but I can state that a part of those ties are actually in use after a service of 17 to 20 years, and that the balance were withdrawn rather in consequence of wear, than from decay of the woody tissue."

Report respecting Creosoting at Leith.

3 East Register Street,

Edinburgh, 26th March, 1862.

Sir:—In consequence of your letter to the Commissioners of the Leith Pier and Harbor Works, they appointed a sub-committee of their Board to inspect the works, and see the state of the creosoted timber, of which the Leith Pier was constructed in 1850.

It was ascertained and admitted by all, that unprepared wood is completely eaten away by the worms, at this place, in three or four years, and that, if the piers and woodwork had not been creosoted, the whole would have been destroyed in four years.

LEITH PIER.

The Main Piles.—These were very carefully examined by Mr. Robertson and the Commissioners' Superintendent, *but in no instance could they find that the worm attacked them.* They were creosoted with ten pounds per foot, and *these piles are* 1013 *in number.*

The beams supporting the deck planks, consisting of forty-two beams, 27 feet long, 13 inches by 16½ inches, were next examined; they appeared to be perfectly sound, except in one instance; this beam was eaten all over, and must have been badly, or not at all, creosoted.

The next were the walings and cross-ties; they were all perfectly sound, *except, in several instances, the ends of them were eaten by the worm; it was only in that part of their ends which had been cut*—the other portions of these pieces were perfectly free from the attack of the worm; they are 13 by 6½ inches, creosoted with seven pounds to the foot.

The iron spikes that were drawn out of the beams with the planks, were the same as if newly made; not the slightest appearance of rust being upon them, although they had been in the wood and sea twelve years. This I pointed out to the Commissioners.

To enable the committee to see the planks properly, several of them were lifted, which showed them to be considerably eaten on the

under side, except the portions that rested on the beams, which had the appearance of being newly creosoted, being wet with oil.

Although these planks have lasted twelve years, I am satisfied that had this low landing slip been laid with deals perfectly dry, in place of planks cut off logs, and impregnated with ten pounds of oil instead of six, there would not have been any decay at all.

These planks are not eaten in the same way as an uncreosoted piece of timber; uncreosoted timber is eaten on all sides, the insects attacking the outside and eating inwards; whereas, in creosoted timber, the insect gets in only at the heart, at the exposed end, and eats to the outside. I am, sir, your obedient servant,

P. M. Moir.

Note.—The total quantity of timber required for repairs of this pier, up to the present date, July, 1864, has been 400 cubic feet.

To obtain information as to the present condition of the Leith piers, I wrote to P. M. Moir, Esq., in May last, and in reply received a letter, from which I make the following extracts:

"*Sterling*, 16*th June*, 1877.

"Edward R. Andrews, Esq., Boston.

"*Dear Sir*:—I have had occasion several times since 1862, to examine the Leith piers, and report upon them; I may say, always in favor of the creosoting process. The main piles stand as sound to-day as the day they were put down; the only portion which has given way or been removed, was the low water slip; this had been imperfectly done at first, but since proper repairs were executed there has been no decay, so far as I am aware."

Mr. Moir further adds:

"I have had a very long experience in creosoting, and can, without hesitation, say that no other method is its equal.

"I may mention that all railways in this country have now their own creosoting establishments, so the trade in private hands is very much reduced.

"I heartily concur in the statement, that timber thoroughly impregnated with creosote oil, becomes practically imperishable.

"Yours, &c.,

"P. M. Moir."

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